I CLAIM:

1. A phase demodulator for measuring a phase difference between a phase-modulated test signal $I_s(\omega t) = 2k_1\cos(\omega t+\phi_s)$ and a phase-modulated reference signal $I_r(\omega t)=2k_2\cos(\omega t+\phi_r)$, the test and reference signals having fixed carrier frequencies (ω), the phase difference ($\Delta\phi$) being equal to ($\phi_s-\phi_r$), said phase demodulator comprising:

an amplitude control device for adjusting amplitudes of the test and reference signals to satisfy the condition $k_1=k_2=k$;

a differential amplifier, coupled to said amplitude control device, for receiving amplitude-adjusted test and reference signals from said amplitude control device, for obtaining an intensity difference between the amplitude-adjusted test and reference signals, and for amplifying the intensity difference to generate an amplitude-modulated output $I_{out}(\omega t)$ equal to $|4\gamma k\sin(½\Delta\phi)|\sin(\omega t)$, where γ is the gain of said differential amplifier; and

a signal processing device including an amplitude demodulator coupled to said differential amplifier, said amplitude demodulator demodulating the amplitude-modulated output from said differential amplifier to obtain an output that is related to the phase difference

($\Delta\phi$).

2. The phase demodulator of Claim 1, wherein said signal processing device further includes a phase comparator, coupled to said amplitude control device, for determining a sign of the phase difference ($\Delta\phi$) from the amplitude-adjusted test and reference signals, and for determining an increasing or decreasing direction of change in the phase difference ($\Delta\phi$).

3. The phase demodulator of Claim 2, wherein said amplitude control device includes a pair of automatic gain control units that receive the test and reference signals, respectively.

4. The phase demodulator of Claim 1, the phase difference ($\Delta\phi$) being further equal to $2n\pi+\delta$, n being an integer, δ being between 0 and π, wherein the amplitude-modulated output $I_{out}(\omega t)$ is further equal to $|4\gamma k\sin(½\delta)|\sin(\omega t)$, and said signal processing device further includes a counter for recording n pulse signals from the amplitude-demodulator output, the phase difference ($\Delta\phi$) being represented by (n, δ) to extend range of measurable phase change, δ being equal to $2\sin^{-1}(|I_{out}|/4\gamma k)$.

5. The phase demodulator of Claim 1, the phase difference

($\Delta\phi$) being equal to $|I_{out}|/2\gamma k$ when the absolute value of the phase difference ($\Delta\phi$) is between 0 and 10°, wherein said signal processing device further includes a differentiator for generating a time-differentiated output $d/dt\ |I_{out}(\omega t)|$ from the amplitude-demodulator output, where $d/dt\ |I_{out}(\omega t)| = 2\gamma k\ d/dt\ |\Delta\phi| = 2\gamma k\omega_s$, and where ($\omega_s$) is equal to $d/dt\ |\Delta\phi|$ and is the instantaneous frequency.

6. The phase demodulator of Claim 1, wherein said signal processing device further includes a feedback loop capable of generating a control signal that corresponds to the phase difference ($\Delta\phi$) for phase difference nulling purposes.

7. A phase difference detector adapted for use with a polarized optical interferometer that generates two mutually orthogonal polarized optical signals, at least one of which is incident upon a test object, the optical signals having equal intensities and carrier frequencies and being processed to obtain two electrical signals that are a function of frequency, time, and phase difference, said phase difference detector comprising:

a differential amplifier adapted to receive the electrical signals, to obtain an intensity difference between the electrical signals, and to amplify the intensity difference to generate an amplitude-

modulated output that is a function of a phase difference between the electrical signals; and

a signal processing device including an amplitude demodulator coupled to said differential amplifier, said amplitude demodulator demodulating the amplitude-modulated output from said differential amplifier to obtain an output that is related to the phase difference.

8. The phase difference detector of Claim 7, wherein said signal processing device further includes a counter such that when the phase difference between the electrical signals exceeds 2π, the phase difference as detected by said signal processing device includes a product of 2π and an integer recorded by said counter.

9. An interferometric system, comprising:

a coherent light source;

an interferometer for separating light from said light source into a signal beam and a reference beam, each of which includes two mutually orthogonal linear polarized components, the signal and reference beams having a beat frequency therebetween, at least one of the components of the signal beam being incident upon a test object, the signal and reference beams being combined and then separated into two mutually orthogonal linear polarized optical heterodyned signals that have equal intensities and equal carrier frequencies and that are a function of the beat frequency, time, and phase

difference between the linear polarized components;

photo detecting means for converting the optical heterodyned signals into two electrical signals;

a differential amplifier coupled to said photo detecting means so as to receive the electrical signals therefrom, said differential amplifier obtaining an intensity difference between the electrical signals, and amplifying the intensity difference to generate an amplitude-modulated output that is a function of a phase difference between the optical heterodyned signals; and

a signal processing device including an amplitude demodulator coupled to said differential amplifier, said amplitude demodulator demodulating the amplitude-modulated output from said differential amplifier to obtain an output that is related to the phase difference.

10. The interferometric system of Claim 9, wherein:

said light source is a single-frequency stabilized laser;

said interferometer including a polarization angle adjusting device for adjusting azimuth angle of the light from said light source, said polarization angle adjusting device being adjustable such that the intensities of the signal and reference beams satisfy the condition $\sqrt{I_{P1}I_{P2}}=\sqrt{I_{S1}I_{S2}}=K$, where I_{P1} and I_{S1} are the intensities of mutually orthogonal linear polarized P_1 and S_1 components of the signal beam, I_{P2} and I_{S2} are the intensities of mutually orthogonal linear polarized P_2

and S_2 components of the reference beam, said interferometer further including a beam splitter for splitting the light from said polarization angle adjusting device into the signal and reference beams, and first and second frequency modulators for modulating the signal and reference beams at different modulating frequencies, respectively, thereby generating the beat frequency ($\Delta\omega$);

one of the optical heterodyned signals being $I_{P1+P2}(\Delta\omega t)$ that includes the P_1 and P_2 components and that is equal to $2K\cos(\Delta\omega t+\Delta\phi_P)$, where $\Delta\phi_P$ is the phase difference between the P_1 and P_2 components, the other one of the optical heterodyned signals being $I_{S1+S2}(\Delta\omega t)$ that includes the S_1 and S_2 components and that is equal to $2K\cos(\Delta\omega t+\Delta\phi_S)$, where $\Delta\phi_S$ is the phase difference between the S_1 and S_2 components;

the magnitude of the amplitude-modulated output being $|4\gamma K\sin(½\Delta\phi)|$, where γ is the gain of said differential amplifier, and $\Delta\phi=\Delta\phi_P-\Delta\phi_S$.

11. The interferometric system of Claim 9, wherein said signal processing device further includes a feedback loop capable of generating a control signal that corresponds to the phase difference ($\Delta\phi$) and that can be used to adjust optical path of at least one of the

components of the signal and reference beams, thereby permitting the phase difference ($\Delta\phi$) to be maintained within a narrow range that encompasses an initial phase difference value ($\Delta\phi_0$).

12. The interferometric system of Claim 10, wherein said signal processing device further includes a phase comparator, coupled to said photo detecting means, for determining a sign of the phase difference ($\Delta\phi$), and for determining direction of change in the position of the test object.

13. The interferometric system of Claim 10, the phase difference ($\Delta\phi$) being further equal to $2n\pi+\delta$, n being an integer, δ being between 0 and π, wherein the magnitude of the amplitude-modulated output of said differential amplifier is further equal to $|4\gamma K\sin(\frac{1}{2}\delta)|$, and said signal processing device further includes a counter for recording n pulse signals from the amplitude-demodulator output, the phase difference ($\Delta\phi$) being represented by (n, δ) to extend range of measurable phase change.

14. The interferometric system of Claim 10, wherein said interferometer further includes a polarized beam splitter for splitting the signal beam into the P_1 and S_1 components, the test object being a ring-type optical

path unit, said polarized beam splitter being disposed between said first frequency modulator and the test object, feeding the P_1 and S_1 components to the test object in opposite directions, and recombining the P_1 and S_1 components from the test object.

15. The interferometric system of Claim 14, wherein said optical path unit includes a plurality of planar mirrors.

16. The interferometric system of Claim 14, wherein said optical path unit includes a polarization maintain single mode optical fiber.

17. The interferometric system of Claim 9, wherein:

said light source is a single-frequency stabilized linear polarized laser;

said interferometer including a polarization angle adjusting device for adjusting azimuth angle of the light from said light source, said polarization angle adjusting device being adjustable such that the intensities of the signal and reference beams satisfy the condition $\sqrt{I_{P1}I_{P2}}=\sqrt{I_{S1}I_{S2}}=\rho$, where I_{P1} and I_{S1} are the intensities of mutually orthogonal linear polarized P_1 and S_1 components of the signal beam, I_{P2} and I_{S2} are the intensities of mutually orthogonal linear polarized P_2 and S_2 components of the reference beam, said interferometer further including a position-movable mirror that moves at a predetermined speed for introducing a Doppler frequency shift to the frequency of at least one of the signal and reference beams, thereby

resulting in the beat frequency between the signal and reference beams;

one of the optical heterodyned signals being $I_{P1+P2}(\Delta\omega t)$ that includes the P_1 and P_2 components and that is equal to $2\rho\cos(\Delta\omega t+\Delta\phi_P)$, where $\Delta\phi_P$ is the phase difference between the P_1 and P_2 components, the other one of the optical heterodyned signals being $I_{S1+S2}(\Delta\omega t)$ that includes the S_1 and S_2 components and that is equal to $2\rho\cos(\Delta\omega t+\Delta\phi_S)$, where $\Delta\phi_S$ is the phase difference between the S_1 and S_2 components;

the magnitude of the amplitude-modulated output of said differential amplifier being $|4\gamma\rho\sin(\frac{1}{2}\Delta\phi)|$, where γ is the gain of said differential amplifier, and $\Delta\phi=\Delta\phi_P-\Delta\phi_S$.

18. The interferometric system of Claim 17, wherein said signal processing device further includes a feedback loop for adjusting optical path of at least one of the components of the signal and reference beams, thereby permitting the phase difference $(\Delta\phi)$ to be maintained within a narrow range that encompasses an initial phase difference value $(\Delta\phi_0)$.

19. The interferometric system of Claim 17, wherein said signal processing device further includes a phase comparator, coupled to said photo detecting means, for

determining a sign of the phase difference ($\Delta\phi$), and for determining direction of change in the position of the test object.

20. The interferometric system of Claim 17, the phase difference ($\Delta\phi$) being further equal to $2n\pi+\delta$, n being an integer, δ being between 0 and π, wherein the magnitude of the amplitude-modulated output of said differential amplifier is further equal to $|4\gamma\rho\sin(\frac{1}{2}\delta)|$, and said signal processing device further includes a counter for recording n pulse signals from the amplitude-demodulator output, the phase difference ($\Delta\phi$) being represented by (n, δ) to extend range of measurable phase change.

21. An interferometric system, comprising:

a coherent light source;

an interferometer for separating light from said light source into a signal beam and a reference beam, each of which includes two mutually orthogonal linear polarized components, the linear polarized components of the signal and reference beams having a beat frequency therebetween, at least one of the components of the signal beam being incident upon a test object, the signal and reference beams being converted into two optical heterodyned signals that have equal intensities and carrier frequencies and that are a function of the beat

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frequency, time, and phase difference between the mutually orthogonal linear polarized components;

photo detecting means for converting the optical heterodyned signals into two electrical signals;

a differential amplifier coupled to said photo detecting means so as to receive the electrical signals therefrom, said differential amplifier obtaining an intensity difference between the electrical signals, and amplifying the intensity difference to generate an amplitude-modulated output that is a function of a phase difference between the optical heterodyned signals; and

a signal processing device including an amplitude demodulator coupled to said differential amplifier, said amplitude demodulator demodulating the amplitude-modulated output from said differential amplifier to obtain an output that is related to the phase difference.

22. The interferometric system of Claim 21, wherein:

said light source is a two-frequency laser;

said interferometer including a beam splitter for splitting the light from said light source into the signal and reference beams, the reference beam including mutually orthogonal linear polarized P_2 and S_2 components having the beat frequency therebetween, the signal beam including mutually orthogonal linear polarized P_1 and S_1 components having the beat frequency therebetween, at least one of the P_1 and S_1 components being incident upon the test object;

said interferometer further including first and second polarization analyzers, each of which receives a respective one of the signal and reference beams, and causes the components of the respective one of the signal and reference beams to interfere with each other along a polarization direction thereof, each of said first and second polarization analyzers having an azimuth angle that is adjustable such that the intensities of the components of the signal and reference beams satisfy the condition $\sqrt{I_{P1}I_{S1}}\sin 2\theta_s=\sqrt{I_{P2}I_{S2}}\sin 2\theta_r=2\chi$, where I_{P1} and I_{S1} are the intensities of the P_1 and S_1 components of the signal beam, I_{P2} and I_{S2} are the intensities of P_2 and S_2 components of the reference beam, θ_s is the azimuth angle of said first polarization analyzer for the signal beam, θ_r is the azimuth angle of said second polarization analyzer for the reference beam;

the optical heterodyned signal $I_{sig}(\Delta\omega t)$ for the signal beam being equal to $2\chi\cos(\Delta\omega t+\Delta\phi_{sig})$, the optical heterodyned signal $I_{ref}(\Delta\omega t)$ for the reference beam being equal to $2\chi\cos(\Delta\omega t+\Delta\phi_{ref})$, where $\Delta\omega$ is the beat frequency, $\Delta\phi_{sig}$ is the phase difference between the P_1 and S_1 components of the signal beam, and $\Delta\phi_{ref}$ is the phase difference between the P_2 and S_2 components of the reference beam;

the magnitude of the amplitude-modulated output of said differential amplifier being $|4\gamma\chi\sin(\frac{1}{2}\Delta\phi)|$, where γ is the gain of said differential amplifier, and $\Delta\phi=\Delta\phi_{ref}-\Delta\phi_{sig}$.

23. The interferometric system of Claim 22, wherein said signal processing device further includes a feedback loop for adjusting optical path of at least one of the components of the signal and reference beams, thereby permitting the phase difference ($\Delta\phi$) to be maintained within a narrow range that encompasses an initial phase difference value ($\Delta\phi_0$).

24. The interferometric system of Claim 22, wherein said signal processing device further includes a phase comparator, coupled to said photo detecting means, for determining a sign of the phase difference ($\Delta\phi$), and for determining direction of change in the position of the test object.

25. The interferometric system of Claim 22, the phase difference ($\Delta\phi$) being further equal to $2n\pi+\delta$, n being an integer, δ being between 0 and π, wherein the magnitude of the amplitude-modulated output of said differential amplifier is further equal to $|4\gamma\chi\sin(\frac{1}{2}\delta)|$, and said signal processing device further includes a counter for recording n pulse signals

from the amplitude-demodulator output, the phase difference ($\Delta\phi$) being represented by (n, δ) to extend range of measurable phase change.

26. The interferometric system of Claim 22, wherein said interferometer further includes a polarized beam splitter for splitting the signal beam into the P_1 and S_1 components, the test object being a ring-type optical path unit, said polarized beam splitter feeding the P_1 and S_1 components to the test object in opposite directions, and recombining the P_1 and S_1 components from the test object.

27. The interferometric system of Claim 26, wherein said optical path unit includes a plurality of planar mirrors.

28. The interferometric system of Claim 26, wherein said optical path unit includes a polarization maintain single mode optical fiber.